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Suk-Gyun HAN et al.

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For: LASER SCANNING UNIT

SUBMISSION OF VERIFIED TRANSLATION OF U.S. PROVISIONAL APPLICATION NO. 60/464,096

Commissioner for Patents
PO Box 1450
Alexandria, VA 22313-1450

Sir:

In accordance with the provisions of 37 CFR 1.53(c), the applicant(s) submit(s) herewith a verified Translation of U.S. Provisional Application No. 60/464,096 in accordance with the requirements of 35 U.S.C. § 1.53(c).

Respectfully submitted,

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IN THE MATTER OF

U.S. Provisional Application No. 60/464,096

By Samsung Electronics Co., Ltd

I, Eun-ah Choi, an employee of Y.P.Lee & Associates of The Cheonghwa Bldg., 1571-18 Seocho-dong, Seocho-gu, Seoul, Republic of Korea, hereby declare that I am familiar with the Korean and English language and that I am the translator of U.S. Provisional Application and certify that the following is to the best of my knowledge and belief a true and correct translation.

Signed this 27th day of May 2003

Eunah Choi

ABSTRACT

[Abstract of the Disclosure]

Provided is a laser scanning unit including a housing, an optical system, a motor and a drive chip. The optical system is installed inside the housing and includes an optical source for emitting a laser beam, a polygon mirror for scanning the laser beam, and a plurality of optical elements for imaging the laser beam on an image surface. The motor is installed inside the housing for rotating the polygon mirror. The drive chip is disposed outside the housing for controlling the motor to be rotated at a constant speed using a sensorless control algorithm. The drive chip controls the motor via the sensorless control algorithm using a back-electromotive force generated by the motor. The drive chip and the motor are connected to power supply lines by back-electromotive force signal lines. Since the drive chip of the polygon mirror motor is disposed outside the housing, an increase in temperature inside the housing due to the drive chip is prevented, and accordingly, a stable optical power is obtained from the laser diode. Moreover, the motor is controlled using the sensorless control algorithm and thus the number of signal lines connecting the drive chip to the motor is reduced, thereby minimizing noise.

[Representative Drawing]

FIG. 4

SPECIFICATION

[Title of the Invention]

Laser scanning unit

[Brief Description of the Drawings]

FIG. 1 is a perspective view illustrating the internal configuration of a conventional laser scanning unit.

FIG. 2 is a block diagram illustrating the circuit configuration of a motor drive chip of the conventional laser scanning unit in FIG. 1.

FIG. 3 is a perspective view of the overall configuration of a laser scanning unit according to the present invention.

FIG. 4 is a block diagram illustrating the circuit configuration of a drive chip of the laser scanning unit in FIG. 3.

FIG. 5 is a diagram illustrating waveforms of back-electromotive forces detected by a back-electromotive force detection circuit of the drive chip in FIG. 4.

<Explanation on Reference numerals for the Major Elements in the Drawings>

110... Circuit board
111... Laser diode
112... Collimating lens
113... Cylindrical lens
114... Polygon lens
115... Fθ lens
116... Image-forming mirror
117... Synchronizing signal detecting mirror
118... Synchronizing signal detecting optical sensor
120... Polygon mirror motor
130... Flexible printed circuit board
140... Motor drive chip
141... Motor starting section
142... Three-phase inverter
143... Back-electromotive force detecting section
144... Speed control section
145... Commutation control section

150... Housing

160... Photoconductive drum

170... Main printed circuit board

[Detailed Description of the Invention]

[Object of the Invention]

[Technical Field of the Invention and Related Art prior to the Invention]

The present invention relates to a laser scanning unit for a printing machine and so on, and more particularly, to a laser scanning unit in which a drive chip of a polygon mirror motor is installed outside a housing.

A laser scanning unit is employed in a printing machine, for example, a laser printer. The laser scanning unit emits laser beams to a surface of a photoconductive medium, such as a photoconductive drum or a photoconductive belt, to form a latent electrostatic image corresponding to an image to be printed.

FIG. 1 is an exploded view illustrating the internal configuration of a conventional laser scanning unit.

Referring to FIG. 1, the conventional laser scanning unit includes an optical system composed of various optical elements. The optical elements include a laser diode (LD) 11 for emitting a laser beam, a collimating lens 12 for collimating a laser beam emitted from the LD 11 so that the laser beam is parallel to or convergent on an optical axis, a polygon mirror 14 for horizontally moving a laser beam which has passed through the collimating lens 12 at a constant linear speed to scan the same, a cylindrical lens 13 for imaging a laser beam on a surface of the polygon mirror 14 in a horizontal linear shape, Fθ lenses 15 having a predetermined refractive index with respect to the optical axis for polarizing a laser beam reflected by the polygon mirror 14 at a constant speed to a main scanning direction and correcting aberration to focus the laser beam on a scanned surface, an image-forming mirror 16 for reflecting a laser beam which has passed through the Fθ lens 15 and imaging the laser beam in the form of dots on a surface of a photoconductive drum 60 of a printing machine, an optical sensor 18 for receiving a laser beam and providing a horizontal synchronization, and a synchronization signal detecting mirror 17 for reflecting a laser beam to the synchronization signal detecting optical sensor 18. Such optical elements are installed inside a housing 50 and sealed so as not to be contaminated with foreign substances, such as dust or flying toner.

A motor 20 for rotating the polygon mirror 14 at a constant speed is installed on a circuit board 30 within the housing 50. A drive chip 40 formed of a semiconductor integrated circuit is mounted on the circuit board 30 to drive and control the motor 20. A circuit board 10 for controlling the LD 11 is disposed inside the housing 50.

FIG. 2 is a block diagram illustrating the circuit configuration of the drive chip of the conventional laser scanning unit in FIG. 1.

Referring to FIG. 2, the motor 20 for rotating the polygon mirror 14 at a constant speed includes three position sensors 21, 22, and 23 and a speed sensor 24. In general, hall sensors are used as the sensors 21, 22, 23, and 24. The drive chip 40 includes a position signal amplifying section 41, a speed signal amplifying and filtering section 42, a speed control section 43, a commutation control section 44, and a three-phase inverter 45. The sensors 21, 22, 23, and 24 are connected to the position signal amplifying section 41 of the drive chip 40 by two signal lines, respectively. The three-phase inverter 45 is respectively connected to terminals u, v, and w of the motor 20 by three power supply lines.

The position signal amplifying section 41 amplifies position signals Sa, Sb, and Sc of a rotor of the motor 20 received from the position sensors 21, 22 and 23 and transmits the amplified signals to the commutation control section 44. The speed signal amplifying and filtering section 42 amplifies and filters a speed signal Sd received from the speed sensor 24 and transmits the amplified and filtered signal to the speed control section 43. The speed control section 43 calculates a control signal to control a rotation speed of the motor 20 in response to the received speed signal and transmits the control signal to the commutation control section 44. The commutation control section 44 controls the inverter 45 in response to the received position signal and the speed control signal. The inverter 45 respectively supplies current in a proper switching order to the terminals u, v, and w of the motor 20 so that the motor 20 is rotated at a constant speed.

In the conventional laser scanning unit constructed as above, since the drive chip 40 which acts as a heat-source is installed inside the housing 50, heat generated in the drive chip 40 affects the LD 11. Accordingly, since the temperature characteristic of the LD 11 is changed, the optical power of the LD 11 cannot be exactly controlled.

To prevent the problem, it is preferable that the drive chip 40 is disposed outside the housing 50 so that the drive chip 40 is isolated from the LD 11. However, in this case, as shown in FIG. 2, since a plurality of signal lines which respectively connect the drive chip 40 to the sensors 21, 22, 23, and 24 included in the motor 20 and the power supply lines which supply electric power to the motor 20 are exposed outside the housing 50, disadvantageously, a severe noise is generated due to an electromagnetic field outside the housing 50.

[Technical Goal of the Invention]

The present invention provides a laser scanning unit in which a drive chip of a polygon mirror motor is disposed outside a housing to obtain a stable optical power from a laser diode without being affected by temperature increase, and a motor is controlled using a sensorless control algorithm to minimize noise.

[Structure of the Invention]

According to an aspect of the present invention, there is provided a laser scanning unit comprising: a housing; an optical system installed inside the housing and including an optical source for emitting a laser beam, a polygon mirror for scanning the laser beam, and a plurality of optical elements for imaging the laser beam on an image surface; a motor installed inside the housing for rotating the polygon mirror; and a drive chip disposed outside the housing for controlling the motor to be rotated at a constant speed using a sensorless control algorithm.

The drive chip may be mounted on a main printed circuit board of a printing machine on which the laser scanning unit is installed, and the drive chip may be electrically connected to the motor by a flexible printed circuit board.

The drive chip may control the motor via the sensorless control algorithm using a back-electromotive force generated by the motor, and in this case, the drive chip and the motor may be connected to power supply lines by back-electromotive signal lines.

The drive chip may include: a motor starting section for generating a starting signal to start the motor; an inverter for applying current to the motor in response to the starting signal; a back-electromotive force detecting section for detecting a back-electromotive force generated according to the rotation of the motor; a speed

control section for recognizing the position of a rotor of the motor and the speed of the motor based on a waveform of the back-electromotive force detected by the back-electromotive force detecting section to generate a speed control signal; and a commutation control section for controlling the inverter in response to the speed control signal.

According to the present invention, since the drive chip of the polygon mirror motor is disposed outside the housing, the temperature inside the housing is prevented from increasing and accordingly a stable optical power is obtained from the laser diode. Moreover, since the motor is controlled using a sensorless control algorithm, the number of signal lines connecting the drive chip to the motor is reduced, thereby minimizing noise.

The present invention will now be described more fully with reference to the accompanying drawings, in which preferred embodiments of the invention are shown.

FIG. 3 is a perspective view illustrating the overall configuration of a laser scanning unit according to the present invention.

Referring to FIG. 3, the laser scanning unit according to the present invention includes a housing 150 having a predetermined internal space, and an optical system installed inside the housing 150 and including a plurality of optical elements.

The housing 150 supports the optical elements constituting the optical system and seals the optical elements so that the optical elements can be prevented from being contaminated with foreign substances, such as external dust or flying toner.

The optical system includes an optical source for emitting a laser beam, a polygon mirror 114 for scanning the laser beam, and a plurality of optical elements, such as lenses and mirrors for imaging the laser beam. As the optical source, a laser diode 111 may be used. The laser diode 111 is controlled by a circuit board 110 on which an optical source control circuit is mounted. A collimating lens 112 and a cylindrical lens 113 are disposed in front of the laser diode 111. The collimating lens 112 collimates a laser beam emitted from the laser diode 111 so that the laser beam is parallel to or convergent on an optical axis, and the cylindrical lens 113 images the laser beam on a surface of the polygon mirror 114 in a horizontal linear shape. The polygon mirror 114 horizontally moves a laser beam that has passed through the collimating lens 112 and the cylindrical lens 113 at a constant linear speed to scan the laser beam. In front of the polygon mirror 114, there are

disposed Fθ lenses 115 having a predetermined refractive index with respect to the optical axis to polarize a beam of a constant speed reflected by the polygon mirror 114 to a main scanning direction and correct aberration to focus the beam on a scanned surface. A laser beam having passed through the Fθ lenses 115 is reflected by an image-forming mirror 116 disposed in front of the Fθ lenses 115 so as to be imaged in the form of dots on a surface of a photoconductive medium, for example, a photoconductive drum 160, which is an image surface of a printing machine. A synchronization signal detecting mirror 117 and an optical sensor 118 are interposed between the Fθ lenses 115 and the image-forming mirror 116 to receive a laser beam and provide horizontal synchronization.

The laser scanning unit according to the present invention includes a motor 120 for rotating the polygon mirror 114 and a drive chip 140 for controlling the motor 120 to be rotated at a constant speed.

A three-phase brushless DC (BLDC) motor is preferably used as the motor 120, but other kinds of motors may be used. The motor 120 is mounted inside the housing 150. Since a separate circuit board does not need to be used for the motor 120, which will be explained hereinbelow, the motor 120 can be directly installed in the housing 150.

The drive chip 140 is formed of a semiconductor integrated circuit including a plurality of circuits for driving and controlling the motor 120. In particular, according to the present invention, while the motor 120 is installed inside the housing 150, the drive chip 140 is disposed outside the housing 150. By way of example, the drive chip 140 may be mounted on a main printed circuit board 170 of the printing machine on which the laser scanning unit according to the present invention is installed. In this case, the drive chip 140 can be electrically connected to the motor 120 by a flexible printed circuit board (FPCB) 130.

According to the present invention, since the drive chip 140 is disposed outside the housing 150, an increase in temperature inside the housing 150 due to heat generated by the drive chip 140 is prevented, and accordingly a stable optical power is obtained from the laser diode 111.

According to the present invention, in order to reduce noise due to an external electromagnetic wave while disposing the drive chip 140 outside the housing 150, the number of signal lines connecting the drive chip 140 to the motor 120 should be minimized. For this purpose, the drive chip 140 is controlled to rotate the motor 120

at a constant speed using a sensorless control algorithm. In the sensorless control algorithm, since the motor 120 does not need to be provided with conventional position sensors and speed sensor, signal lines connecting the sensors to the drive chip 140 are not required.

Accordingly, according to the present invention, the number of signal lines connecting the motor 120 installed inside the housing 150 to the drive chip 140 disposed outside the housing 150 is reduced, thereby minimizing noise. Furthermore, the laser scanning unit according to the present invention does not employ position sensors and a speed sensor, such that a separate circuit board for the motor 120 is not required, leading to reduction in manufacturing costs.

There are many algorithms that can be used as the sensorless control algorithm. One example using a back-electromotive force generated by the motor will be explained in short with reference to FIGS. 4 and 5.

FIG. 4 is a block diagram illustrating the circuit configuration of the drive chip according to the present invention, and FIG. 5 is a diagram illustrating waveforms of back-electromotive forces detected by the back-electromotive force detecting circuit in FIG. 4.

Referring to FIG. 4, the drive chip 140 mounted on the main printed circuit board 170 of the printing machine includes a motor starting section 141, a three-phase inverter 142, a back-electromotive force detecting section 143, a speed control section 144, and a commutation control section 145. The three-phase inverter 142 is respectively connected to terminals u, v, and w of the motor 120 by three power supply lines L1, L2, and L3. The back-electromotive force detecting section 143 is connected to the motor 120 by one back-electromotive force signal line L4.

The motor starting section 141 generates a starting signal to start the motor 120, and the inverter 142 applies current to the motor 120 in response to the starting signal to start the motor 120. As the motor 120 is rotated, a back-electromotive force is generated. The generated back-electromotive force is detected by the back-electromotive force detecting section 143. At this time, as shown in FIG. 5, waveforms of back-electromotive forces Pu, Pv, and Pw in respective phases u, v, and w detected by the back-electromotive force detecting section 143 have a phase difference of 120° therebetween. The speed control section 144 senses respective points where the waveforms of the back-electromotive forces Pu, Pv, and Pw are

passed through a level 0 to recognize the position of a rotor of the motor 120, and recognizes the rotation speed of the motor 120 based on amplitude and time interval between respective phases to output an appropriate speed control signal. The output speed control signal is transmitted to the commutation control section 145. The commutation control section 145 controls the inverter 145 in response to the received speed control signal. The inverter 145 accordingly respectively supplies current in a proper switching order to the terminals u, v, and w of the motor 120 to rotate the motor 120 at a constant speed.

As aforementioned, according to the present invention, the drive chip 140 mounted on the main printed circuit board 170 of the printing machine is connected to the motor 120 installed inside the housing 150 by the three power supply lines L1, L2, and L3 and the back-electromotive force signal line L4. Therefore, the number of signal lines is considerably reduced as compared with the conventional art, thereby minimizing noise generated due to an external electromagnetic wave.

[Effect of the Invention]

As described above, the present invention has an advantage in that the drive chip of the polygon mirror motor is disposed outside the housing and thus an increase in temperature inside the housing due to heat generated by the drive chip is prevented, and accordingly, a stable optical power is obtained from the laser diode.

The present invention has another advantage in that the motor is controlled using the sensorless control algorithm and thus the number of signal lines connecting the drive chip to the motor is reduced, thereby minimizing noise.

The present invention still has another advantage in that a plurality of sensors which are used in the conventional laser scanning unit are not required in the laser scanning unit according to the present invention, and accordingly, manufacturing costs are reduced.

What is claimed is:

1. A laser scanning unit comprising:

a housing;

an optical system installed inside the housing and including an optical source for emitting a laser beam, a polygon mirror for scanning the laser beam, and a plurality of optical elements for imaging the laser beam on an image surface;

a motor installed inside the housing for rotating the polygon mirror; and

a drive chip disposed outside the housing for controlling the motor to be rotated at a constant speed using a sensorless control algorithm.

2. The laser scanning unit of claim 1, wherein the drive chip is mounted on a main printed circuit board of a printing machine on which the laser scanning unit is installed.

3. The laser scanning unit of claim 1, wherein the drive chip is electrically connected to the motor by a flexible printed circuit board.

4. The laser scanning unit of claim 1, wherein the motor is a three-phase brushless DC motor.

5. The laser scanning unit of claim 1, wherein the drive chip controls the motor via the sensorless control algorithm using a back-electromotive force generated by the motor.

6. The laser scanning unit of claim 5, wherein the drive chip and the motor are connected to power supply lines by back-electromotive force signal lines.

7. The laser scanning unit of claim 4, wherein the drive chip includes:

a motor starting section for generating a starting signal to start the motor;

an inverter for applying current to the motor in response to the starting signal;

a back-electromotive force detecting section for detecting a back-electromotive force generated according to the rotation of the motor;

a speed control section for recognizing the position of a rotor of the motor and the speed of the motor based on a waveform of the back-electromotive force

detected by the back-electromotive force detecting section to generate a speed control signal; and

a commutation control section for controlling the inverter in response to the speed control signal.

FIG. 1 (PRIOR ART)

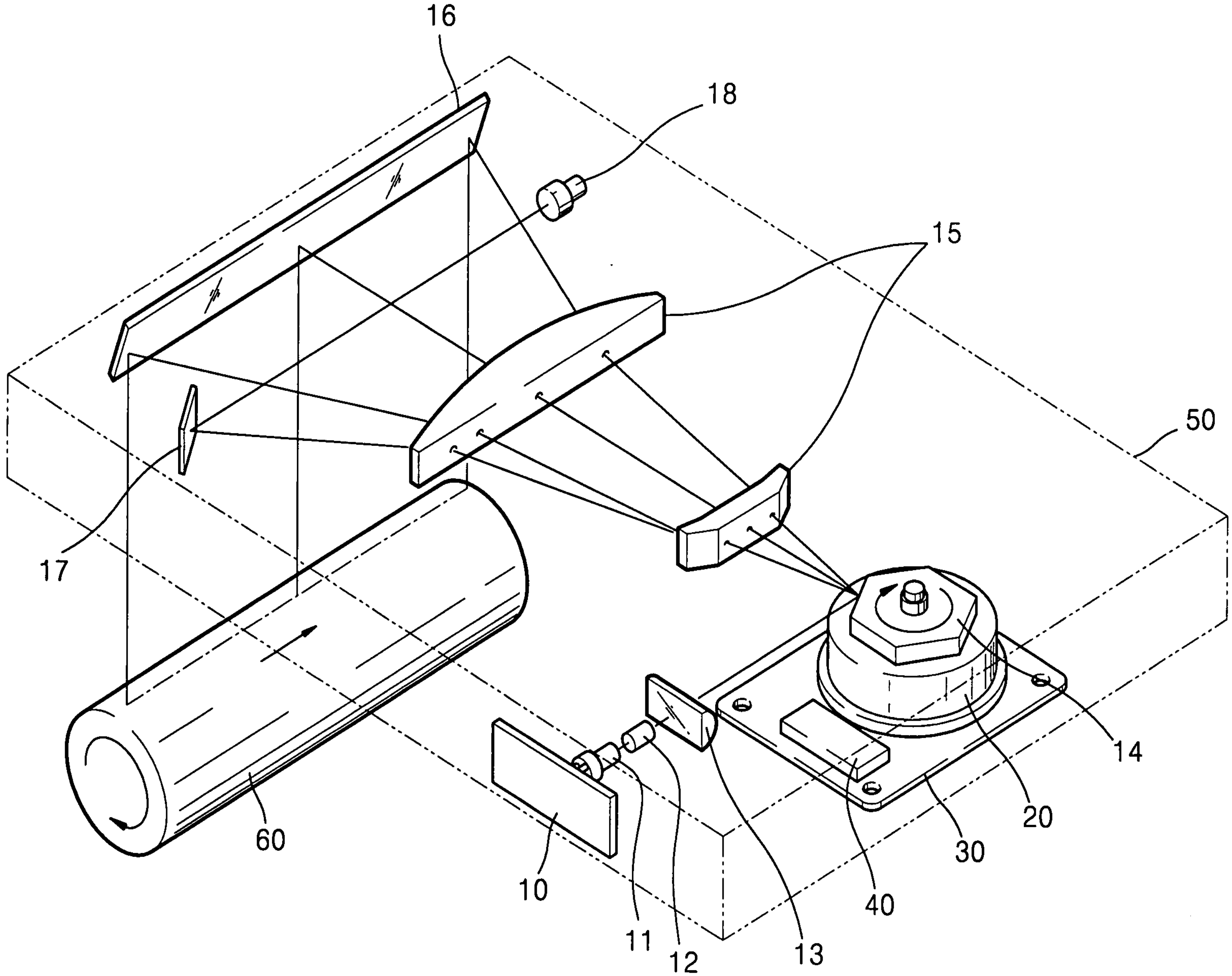

FIG. 2 (PRIOR ART)

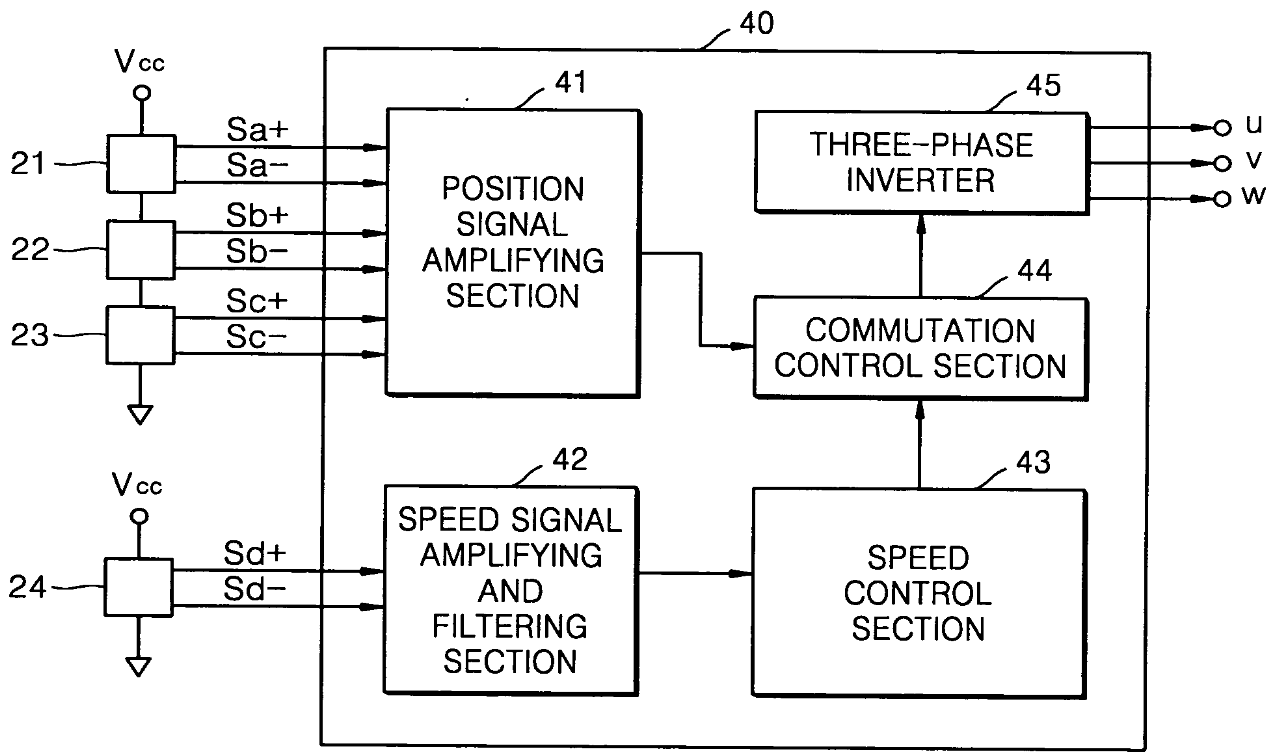

FIG. 4

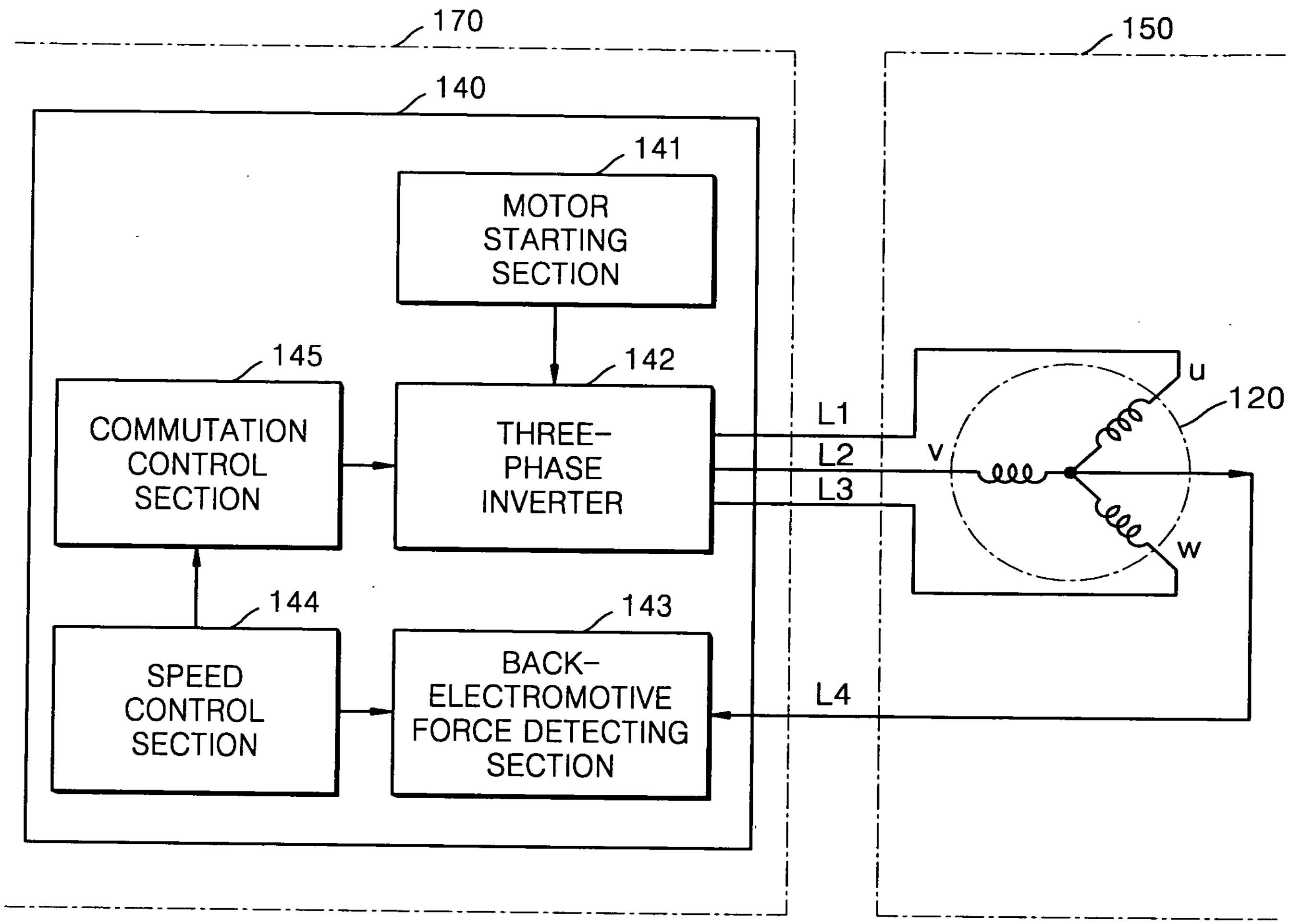
170
150
140
141
MOTOR STARTING SECTION
145
142
COMMUTATION CONTROL SECTION
THREE-PHASE INVERTER
L1
L2
L3
u
v
w
120
144
143
SPEED CONTROL SECTION
BACK-ELECTROMOTIVE FORCE DETECTING SECTION
L4

FIG. 5

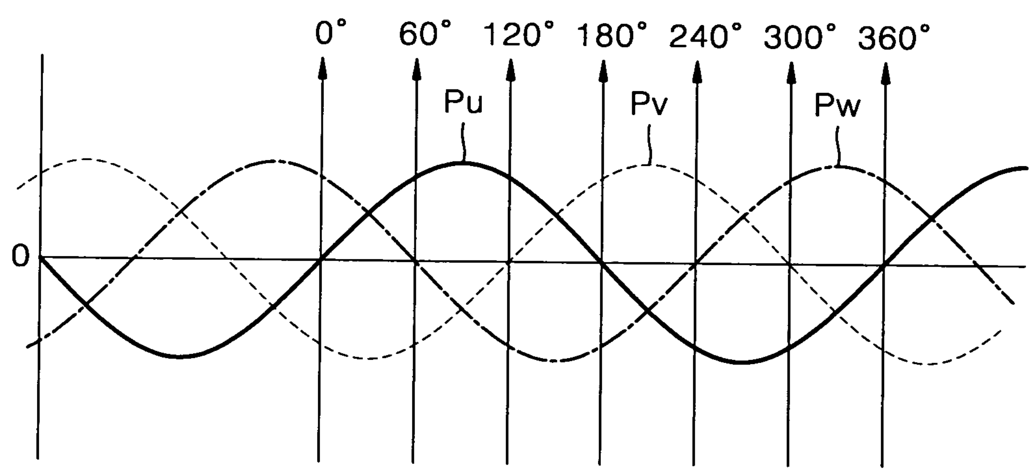
0°
60°
120°
180°
240°
300°
360°
Pu
Pv
Pw
0

FIG. 3